iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 Issue: V Month of publication: May 2024

DOI: https://doi.org/10.22214/ijraset.2024.62324

Study on Sugarcane Bagasse Biochar in Concrete for Carbon Sequestration

Vikram R. Tirpude
Government College of Engineering, Amravati

Abstract:** Embodied carbon from manufacturing of cement is increasing day by day as constructions are happening everywhere so the consumption of cement is increasing by default. In next decade there are much more constructions are going to takes place that will lead to Increase in GHG's emissions from cement manufacturing. It is supposed to be a threat to climate . To reduce this increase in embodied carbon there is need to reduce cement consumption by partially replacing cement with other suitable options. biochar which is a by-product of pyrolysis of biomass and is effective in carbon sequestration activity and results in high water and carbon dioxide holding capacity. In this study Sugarcane bagasse biochar is used in concrete and mortar as partial replacement of cement for carbon sequestration. Strength characteristics of materials are supposed to be interlinked with pozzolanic activity hence pretreatment is done with 0.1 N HCl to enhance pozzolanic property activity of biochar. This pozzolanic activity is calculated by considering $Ca(OH)_2$ fixation during the titration in chapelle test. From the study results its is observed that pretreatment with 0.1 N HCl at room temperature is sufficient to increase the pozzolanic activity of biochar also this Sugarcane bagasse biochar is observed to be sequestering carbon dioxide and it is increasing with increase in biochar. But compressive strength of concrete is decreasing with increase in sugarcane bagasse biochar. Hence it is not suitable to be used in construction work but can be used in plaster mortar where no much compressive strength is required . Sugarcane bagasse biochar can act as carbon sequestering media in concrete but it can't be recommended in concrete or mortar for construction work.
***Keywords:** Biochar, Sugarcane bagasse, Carbon Sequestration, Pozzolanic Activity, Embodied carbon ,Cement Replacement.*

I. INTRODUCTION

While working on air pollution control, the attention is always given to operational carbon , while embodied carbon is always neglected. Embodied carbon from manufacturing processes of various building materials like cement , steel, glass etc lead to impact on global air pollution. As a result we observe that 39 % of the GHG's emissions is a embodied carbon[1]. While India is second largest cement producing country leads worry about GHG's emissions and climate change. Nearer to 8% of total GHG's emissions are observed to be emitted in cement production process.[2] World is in a need to reduce cement consumption as early as possible. Various replacements has been done before in various studies while in most of them strength considerations are observed to be in reducing. Biochar which are proved to be having carbon sequestration properties can be a better solution to this and to make building materials as a carbon sink. [3]

Biochars are considered to be having high water and carbon dioxide holding capacity[4]. Where nowadays we find biochars are getting used in soil to enhance soil properties. Coconut shell biochar is already found to be suitable to be used as partial replacement in concrete with better strength gain and high carbon sequestration. [5]

In this study, Sugarcane bagasse biochar is considered for study and checked if it is liable to carbon sequestration with partial replacement of cement in cement mortar and cement concrete. Previously sugarcane bagasse has been used in self compacting concrete[6]. As pozzolanic property is considered to the meter of strength gain, pozzolanic property of biochar is calculated in this study also pretreatment with 0.1N, 0.5N, 1 N is done to enhance the pozzolanic activity of sugarcane bagasse biochar, respective change in pozzolanic property is observed with increase in normality and increase in temperature. And carbon sequestration is measured by MQ 135 sensors[7] in specially prepared airtight chamber.

II. MATERIALS AND METHODS

A. Biochar Production

In this study Sugarcane bagasse is collected from nearer sugarcane juice shops. Initially it is kept for drying for 2 days . then this sugarcane bagasse is shredded and converted to biochar by pyrolysis process [8] at a controlled temperature in the range of 350˚C to 400˚C.Biochar is then Grounded manually to the size less than 180 microns.

Fig.1 Sugarcane bagasse Biochar Production

B. Pre-treatment

To enhance the pozzolanic activity of Biochar , pretreatment was done with 0.1 N HCl [9]. Sugarcane Bagasse biomass is immersed in HCl solution for 60 minutes at room temperature and to check change in pozzolanic activity with increase in temperature, pretreatment of another samples of sugarcane bagasse are done at 100 ˚C too. Pretreatment is done with increasing normality of HCl i.e at 0.1 N, 0.5N, and 1 N respectively. After Pretreatment is done biomass is washed with distilled water and oven dried. Then this biomass is converted to Biochar with the help of pyrolysis unit.

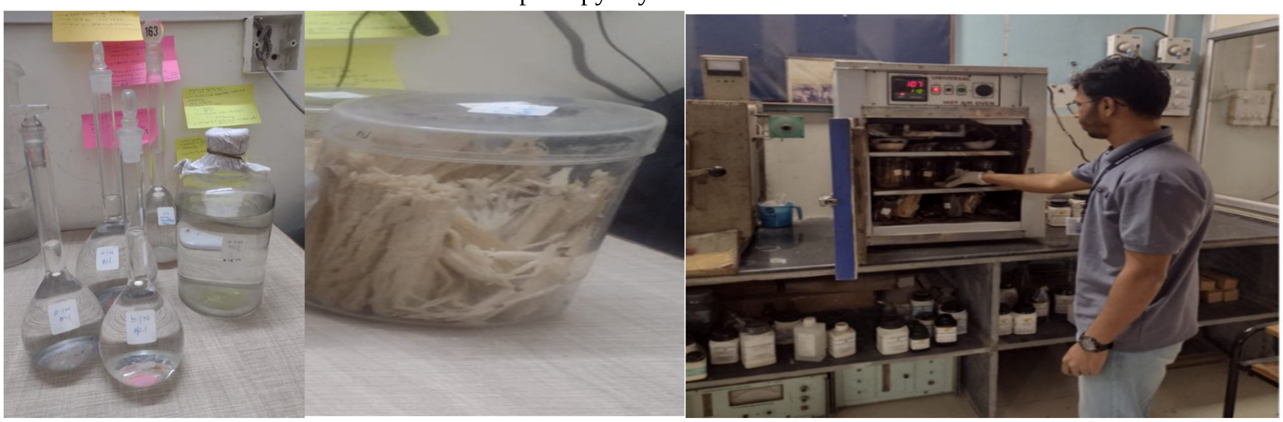

Fig.2 Sugarcane Bagasse pretreatment before Biochar Production

C. Pozzolanic Activity measurement

Chapelle test is used in this study (N.F P18-513) which is a french test for pozzolanic activity measurement . 250 ml deionised water with 1 gm of biochar and 2 gm of calcium oxide powder is added to it and kept for continuous stirring for the period of 16 hours at 90˚C by keeping it in hot stirring plate. Slurry was allowed to cool after 16 hours and then 250 ml of 0.7 M sucrose was added to it with stirring for 15 minutes and followed by filtration and suspension. Few drops of phenolphthalein is added to 25 ml of filtrate and and followed by titration with 0.1 N HCl. Titration results define pozzolanic activity measurement .

$$Ca\,(OH)_2 \text{ fixed in mg} = 2\,\frac{(V_b - V_m)}{V_b}\,\frac{74}{56} * 1000$$

Where, *Vm* is the volume of 0.1 N HCl solution required for sample with biochar and *Vb* is the volume of 0.1 N HCl solution required for sample without biochar. [9]

D. Carbon sequestration Testing

Mortar cubes with 2%, 4%, 6% amendments are used in the study. [10] for the measurement of Carbon sequestration i.e percentage sorption of carbon diaoxide. And concrete cubes with 5%, 10% and 15% amendment of biochar are considered to check compressive strength of concrete (M20 grade).[11]

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue V May 2024- Available at www.ijraset.com

Fig.3 mortar cubes and concrete cube after Sugarcane Bagasse biochar enrichment

E. Properties of cement (used in the study)

1) grade - OPC 43 (Ultratech)
2) Specific gravity of Cement = 3.13
3) Fineness - 6%
4) Standard consistency - 32%
5) Initial setting time - 175 min.
6) Final setting time - 310 min.

F. Test Results for Sugarcane bagasse Biochar

1) Size - 150 microns down-size.
2) pH- 9.06
3) Specific gravity - 2.08

G. Carbon sequestration study

For carbon sequestration study , Airtight chamber is prepared with 8mm thick transparent Acrylic sheets having two rooms (Room 1 and Room 2). To check if it is air tight, after preparing a closed chamber it is submerged into water and checked for water entry and that area is sealed with M-seal and checked again.

After preparing a Airtight chamber , 7.5 cm x 7.5 cm openings are made in both rooms for the entry of cubes , candles into the rooms. MQ 135 sensors are attached on the top of the chamber by fixing Arduino Uno and LED assembly at top and sensors fixed upside down into rooms into the holes made on airtight chamber . holes with sensors are again filled with sealing coates to refrain air entry or exit of CO_2 from chamber . Double candle with single specimen per room is considered for carbon sequestration study.

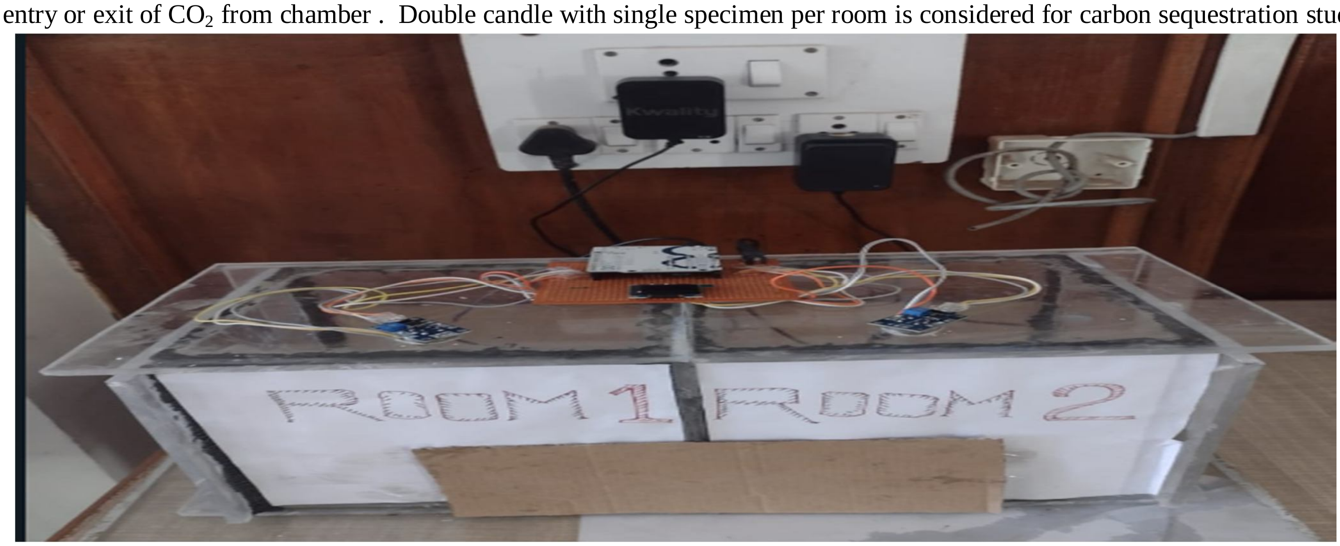

Fig.4 Carbon sequestration study chamber with MQ 135 sensors

III. OBSERVATIONS, RESULTS AND DISCUSSION

A. *Pozzolanic Activity*

The calcium hydroxide formed during titration in mg gives the measurement of the pozzolanic activity.

Table 1. Pozzolanic activity observations

Biochar Description	Trial No.	Vb in ml	Vm in ml	$Ca(OH)_2$ Fixed in mg.	Average $Ca(OH)_2$ Fixed in mg
Untreated Biochar	Trial 1	18.2	17.10	159.73	178.76
	Trial 2	18.6	17.40	170.51	
	Trial 3	18.35	16.90	206.03	
	Vb value is not measured again as no difference in method is observed , hence average of upper 3 trials (I.e 18.40 ml) is considered ahead as Vb for further calculations of treated biochar .				
Treated Biochar 0.1 N HCl R. T - 60 MIN	Trial 1	18.4	15.90	359.08	342.84
	Trial 2	18.4	15.65	395.99	
	Trial 3	18.4	15.80	373.45	
Treated Biochar 0.1 N HCl 100˚C - 60 MIN	Trial 1	18.4	16.10	330.35	361.47
	Trial 2	18.4	15.70	387.81	
	Trial 3	18.4	15.85	366.26	
Treated Biochar 0.5 N HCl R.T - 60 MIN	Trial 1	18.4	16.00	344.72	354.30
	Trial 2	18.4	15.80	373.45	
	Trial 3	18.4	16.00	344.72	
Treated Biochar 0.5 N HCl 100˚C - 60 MIN	Trial 1	18.4	16.20	315.99	337.54
	Trial 2	18.4	16.00	344.72	
	Trial 3	18.4	15.95	351.90	
Treated Biochar 1 N HCl R.T - 60 MIN	Trial 1	18.4	15.90	359.08	344.72
	Trial 2	18.4	16.10	330.35	
	Trial 3	18.4	16.00	344.72	
Treated Biochar 1 N HCl 100˚C - 60 MIN	Trial 1	18.4	15.75	380.63	371.05
	Trial 2	18.4	15.60	402.17	
	Trial 3	18.4	16.10	330.35	

No inferensive change is observed with increase in temperature or Normality of HCl in pretreatment in enhancing pozzolanic activity of biochar . But untreated biochar shows $Ca(OH)_2$ formation of 178.76 mg. Where Treated bichar with 0.1 N HCl at room temperature for an hour shows $Ca(OH)_2$ formation of342.84 mg leading to more than 2 times growth in pozzolanic activity. pretreatment with 0.1 N HCl at room temperature for 60 min. is considered as most economically beneficial for enhancing the pozzolanic activity of biochar.

B. *Carbon Sequestration*

Results of carbon sequestration by Mortar specimen enriched with Sugarcane bagasse biochar are shown below in table 2. Where percentage sorption of carbon dioxide is checked with double candle , single specimen setup.

Table 2 Carbon Sequestration observation

	Trials	Initial concentration of CO_2 (PPM)	Peak concentration of CO_2 (PPM)	Final Concentration of CO_2 (PPM)	Percentage Sorption of CO_2 (%)	Average Percentage Sorption of CO_2 (%)
Control specimen (No Biochar)	Spec. 1	410	574	560	8.53	8.32
	Spec. 2	412	572	558	8.75	
	Spec. 3	410	579	566	7.69	
Cement + 2% biochar	Spec. 1	408	548	531	12.14	11.82
	Spec. 2	415	557	542	10.56	
	Spec. 3	412	553	535	12.76	
Cement + 4% biochar	Spec. 1	420	560	534	18.57	20.74
	Spec. 2	421	552	527	19.08	
	Spec. 3	416	591	548	24.57	
Cement + 6% biochar	Spec. 1	417	584	538	27.54	28.49
	Spec. 2	426	567	529	26.95	
	Spec. 3	410	581	528	30.99	

Carbon sequestration of mortar cube with biochar (pretreated with 0.1 N HCl at room temperature for 60 minutes) is obtained to be trice at 6% of biochar than mortar cube without biochar. Carbon sequestration is observed to be increasing with increase in percentage biochar. It shows that with Sugarcane bagassel biochar enrichment, carbon sequestration is possible and building material that is concrete can act as a carbon sink.

Table 3. Compressive strength Test results on biochar enriched concrete (M20 grade)

Specimen Specification	Trials	Load (KN)	Area of cube (mm2)	28 days compressive strength N/mm2	Average Compressive strength in N/mm2
Control Specimen (No Biochar)	Spec. 1	476	22500	21.15	20.66
	Spec. 2	462	22500	20.53	
	Spec. 3	457	22500	20.31	
Cement + 5% biochar	Spec. 1	475	22500	21.11	20.62
	Spec. 2	460	22500	20.44	
	Spec. 3	455	22500	20.22	
Cement + 10% biochar	Spec. 1	447	22500	19.86	19.95
	Spec. 2	452	22500	20.08	
	Spec. 3	448	22500	19.91	
Cement + 15%	Spec. 1	425	22500	18.88	18.91

biochar	Spec. 2	424	22500	18.84	
	Spec. 3	428	22500	19.02	

It shows that sugarcane bagasse biochar is reducing the compressive strength of concrete with increase in biochar. hence it is not reliable to be considered for use in concrete maybe it is possible to use it in concrete where there is no requirement of strength . works like footpath base concrete or just in plastering mortar on ground platforms where no much concrete strength is required.

IV. CONCLUSION

This study deals with sugarcane bagasse biochar in mortar and concrete for carbon sequestration. As in results it is found that this sugarcane bagasse is liable to carbon sequestration and can be used as enrichment in in concrete to reduce cement consumption and it can act as potential sequestration media to deal with embodied carbon and green house gas emissions . Though with pretreatment of 0.1 N HCl it is observed that pozzolanic activity is increasing but at the same time it is reducing its compressive strength of concrete with increase in biochar more than 5 % . So Sugarcane bagasse biochar can be used in concrete only for the purpose of carbon sequestration and not for strength consideration. Probably in mortars for plastering work it is considerable that too below 5 % and not more than that.

REFERENCES

[1] Fang D., Brown N., De wolf C. and Mueller C, “Reducing embodied carbon in structural systems : A review of early stage design strategies” Journal of building Engineering, Elsevier, volume 76, October 2023.
[2] Jr. Pelitones palcis R.,”Carbon emissions of concrete manufacturers :- Effect on climate and strategies for reduction”, Researchgate, June 2023.
[3] Galina Churkina, Alan Organschi, Christopher P. O. Reyer, Andrew Ruff, Kira Vinke, Zhu Liu, Barbara K. Reck, T. E. Graedel & Hans Joachim Schellnhuber ., “Buildings as a global carbon sink ”Nature Sustainability volume 3, pages 269–276 (2020)
[4] Gondim R., Celli R., Muniz C., and Calos E. “Explaining the water holding capacity of biochar by scanning electron microscope images” Researchgate, October 2018.
[5] Nair J.,Shika S., and Sreedharan V., “Biochar amended concrete for carbon sequestration”International conference on Materials , mechanics and structures 2020.
[6] Wagh M., Waghe U., “Development of self compacting concrete blended with sugarcane bagasse ash” ScienceDirect, Volume 60, part 3, 2022.
[7] Neamah F., Intisar M. and Zainab K., “ Capable of gas sensor MQ-135 to monitor the air quality with Arduino Uno” International journal of Engineering , research and technology, November 2020.
[8] Elkhalifa S,., Alansari T., and Mackey H., “Food waste to biochars through pyrolysis: A review” Elsevier, Resources, conservation and recycling . volume 144, May 2019.
[9] Zeidabadi Z A, Bhakhtiari S, Abbaslou H and Ghanizadeh A R 2018 Synthesis characterization and evaluation of biochar from agricultural waste biomass for use in building materials Construction and Building Material
[10] IS 4031- 1988 (part 6) “Methods of physical tests for hydraulic cement”.
[11] IS 516- 1959 (Reaffirmed 2004) “Methods of tests for strength of concrete”.